A Novel Oil Spill Detection Approach on Terrestrial Area: A Case study in Alberta

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Abstract

In the field of petroleum industry, one of the most environmental threatened issues is oil spill. While the value of earth observation data has been well reported and operationally applied for maritime spill, it has been much less investigated for terrestrial (land-based) events. Unfortunately, traditional approaches for oil spill detection and monitoring are mostly destructive, time and cost consuming. Remote sensing is an efficient tool that suggests a non-destructive approach. This study aims to investigate oil spill detection on land using remote sensing techniques in Alberta, Canada. For this purpose both proximal (EM-38) and earth observation sensors (Unmanned Arial Vehicle (UAV)) are used. The correlation between EM data and UAV images in different bands is analyzed. The result shows acceptable correlation between different bands of UAV images, soil indexes and EM data. As a result, the UAV images and related indexes can be widely used for monitoring oil and gas pipelines. This research is in its early stages and we are developing more indices/ techniques for pipeline leakage monitoring using remote sensing with focus on UAV imagery and EM data. The preliminary results are promising and showing a great potential of the effectiveness of remote sensing and EM data for monitoring pipelines and leakage detection.

Background and Relevance

Remote sensing tools and technologies present a broad range of analytical techniques and data applicable in the various environmental applications and disaster management (Tucker et al., 1985). In the field of petroleum industry, one of the most environmental threatened issues is oil spill. There are several remote sensing studies which addressed the detection of oil spills in the aquatic area (Brekke et al., 2005). However, oil spill detection in terrestrial area was not in the center of attention by scientist communities, while it can be detected using remote sensing data.

Pipeline leakage has large economic and environmental effects. Thus, the method should be developed to investigate pipeline seepages as soon as possible (Solberg et al., 2007). There are some traditional approaches for detecting the oil spills and their resulting pollution, but most of them are destructive, time and cost consuming (Goodman, 1994). Remote sensing is an efficient tool that suggests a non-destructive approach. Optical remote sensing sensors have high potential to investigate the pipeline leakage on the terrestrial regions (Olson et al., 2001). This study aims to detect oil spills using remote sensing techniques on the terrestrial areas. For this purpose, both proximal and earth observation sensors are used.

Methods and Data

One of the most important factors in the oil spill detection on the terrestrial area is soil salinity parameter which refers to surface or near-surface accumulation of salts (Ijah et al., 1992). In the last decade, a widespread application of remote sensing data can be seen to map soil salinity, either directly from bare soil or indirectly from vegetation (Swift and Mcintosh, 1983). Moreover, soil electrical conductivity is measured using a remote sensing technique, electromagnetic induction (EM) methodology, which is related to the soil salinity (Shrestha, 2006). EM surveys use an instrument called an electromagnetic induction meter that transmits an electromagnetic wave into the ground and determines soil conductivity (Zegelin et al., 1989). Soil apparent electrical conductivity (ECa) is measured by the widely used conductivity meters EM-38 instrument as a proximal sensor (Lega et al., 2012). Advanced techniques and technologies of remote sensing are coincided with developed image processing software and provide a unique opportunity to monitor the environmental hazards (Peter et al., 2014). Unmanned Aerial Vehicles (UAV) is one of the most important promising remote sensing tools that provide a significant improvement over the traditional aerial platforms. Now days, a large number of commercial small-scale airborne platforms are used as a low-cost aerial remotely sensed data (Lin et al., 2011). The UAV imaging system which has visible and near infrared sensors are used as earth observation data over Alberta, Canada. It should be noted that adding salt to oil in pipelines are helpful for better oil flowing (Mishra et. al, 2012). Thus, in the case of oil leakage in the terrestrial area, it is expected that the surrounding soils have higher salinity (Dickins et al., 2008). Therefore, some salinity indexes are exploited. Also, by using UAV data some soil indexes are extracted. The correlation between EM data and UAV images in different bands, salinity, and soil indexes is analyzed. The objective of this study is to analyze the oil pollution in Alberta, Canada, using proximal and UAV remote sensing data.

Results

Using the Equation (1), the correlation between EM and UAV data is obtained (Nielsen, 2002):

$$\gamma = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2}\sqrt{\sum(y_i - \bar{y})^2} \qquad (1)$$

Table I represents the correlation between different UAV bands and EM data. As it can be seen NIR, red, green, and blue bands represents higher correlation with EM data, respectively. Using the first two bands which show higher correlation with EM-38 data, a salinity index can be defined using the following equation:

$$\text{Salinity Index (SI)} = \frac{\text{R}}{\text{NIR}} \times 100 \qquad (2)$$

TABLE I
THE CORRELATION BETWEEN DIFFERENT UAV BANDS AND EM-38.

	EM-38
Red	0.3341
Green	0.3239
Blue	0.2393
NIR	0.3752
Salinity index	0.5603

Table I also shows that salinity index has higher correlation than other bands. Thus, it can be used to detect oil contaminated areas in loss of EM data.

Conclusions

In this study, the UAV images in different bands, red, green, blue, and NIR, and EM-38 data are used. The correlation analysis between the UAV and EM-38 is performed to detect oil spills leakage in Alberta, Canada. The soil contaminated areas is expected to be saltier than area surrounded it. The result shows well agreement with this assumption since the higher correlation can be seen between salinity index and EM data. More specifically, by defining the salinity index and applying correlation analysis, 33% improvement can be seen in comparison with the highest correlated band (Blue) and EM data. Thus, by having the optical imagery and extracting salinity index, the oil contaminated soil can be detected over the large area with an acceptable accuracy.

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